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Biological removal of iron and manganese in rapid sand filters – Process understanding of iron and manganese removal

Biological removal of manganese and iron in rapid sand filters

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In Denmark and many other European countries, drinking water is exclusively or mainly based on groundwater. Treatment of the groundwater is rather simple, only including aeration and a subsequent filtration process. The filtration process may take place over two steps. Step 1: Filtration in a pre-filter, where iron is removed. Step 2: Filtration in an after-filter where e.g. ammonium and manganese is removed. The treatment relies on microbial processes and may present an alternative, greener and more sustainable approach for drinking water production spending less chemicals and energy than chemical (e.g. flocculation) and physical (e.g. membrane filtration) based technologies.

The removal of dissolved manganese and iron is important. If manganese and iron enter the distribution system, the water will become coloured and have a metallic taste, and it may cause problems in the distribution network due to precipitation and corrosion.

Manganese and iron can either be removed physico-chemically or biologically or combined. The physico-chemical oxidation and precipitation of manganese can theoretically be achieved by aeration, but this process is slow unless pH is raised far above neutral, making the removal of manganese by simple aeration and precipitation under normal drinking water treatment conditions insignificant. Manganese may also be oxidized autocatalytically. Iron is usually easier to remove. First, iron is rapidly chemically oxidized by oxygen at neutral pH followed by precipitation and filtration.

The start-up of new filters is often based on “rules of thumb” procedures. New filters are often inoculated with sand from existing filters or backwash sludge, but this results in unpredictable start-up of filter performances. To obtain a well-functioning filter with biological manganese or iron removal, it is essential to ensure that the required microorganisms are present and that both the physical and the nutritional requirements of those organisms are fulfilled. However, the knowledge on the microbiology and processes in rapid sand filters is limited, especially on which parameters affect the biological processes and the interaction between them. Some studies have indicated a direct competition between iron and ammonium removal when oxygen is limited, and both processes may have a negative effect on the manganese removal (de Vet et al., 2009; Tekerlekopoulou et al., 2008). However the reasons for these effects remain unclear.

The aim of this study was to develop a batch assay to quantify microbial manganese and iron removal and to investigate the effect of interactions between the manganese and iron removal processes. The assay is now developed and allows testing of various parameters as well as distinguishing between biological and non-biological removal processes. Results with filter material from a water works, Islevbro, showed that there was a significant difference in manganese removal throughout a filter with highest removal in the top and that the biological removal contributed to the overall manganese removal. Iron had a negative effect on manganese removal and even caused an increase in manganese concentration (release). Experiments with filter material from another water works, Astrup, specially designed to remove iron biologically, showed that the biological iron removal increased the overall iron removal. The results also showed that pH and oxygen level are important parameters. When filter material was treated with sodium azide to inhibit microbial activity, less iron(II) was adsorbed to the filter material, indicating that iron oxidizing bacteria contributed to the oxidation of iron(II) to iron(III).

References

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- Tekerlekopoulou, A.G. et al. (2008) Biological manganese removal from potable water using trickling filters. *Biochemical Engineering Journal* **38**: 292–301.